

VISIT...

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Electrocardiogram (ECG)

Introduction

Definition: Recording the electrical activity of the heart

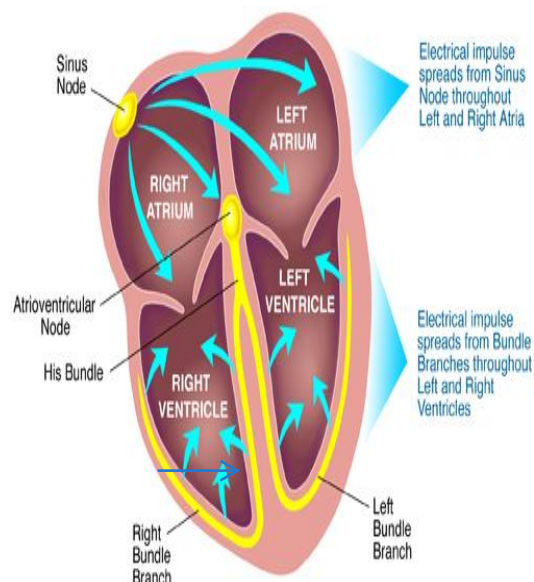
Heart has two types of actions:

Mechanical : contraction & relaxation

Electrical : Depolarization & Repolarization

Mechanism of conduction:

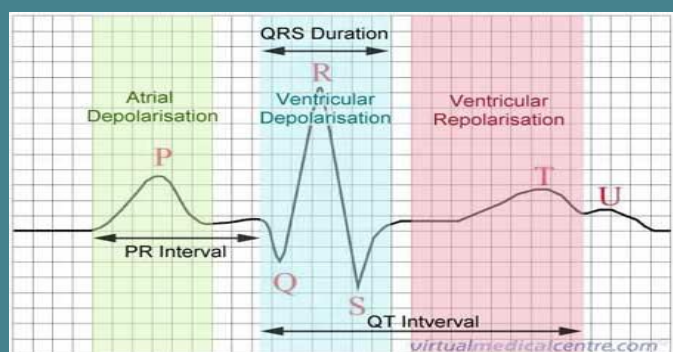
Impulses from SAN excite both atria → AVN (slow conduction) → AVB → Right & left BB → Purkinje fibers → Ventricular wall .



P wave : Atrial depolarization
QRS complex : ventricular depolarization
PR interval : AV conduction
T wave : ventricular repolarization

N.B :

Atrial repolarization is masked by QRS complex .



ECG leads: 12 leads

1) 6 Limbic leads:

record cardiac potentials conducted in the coronal plane .

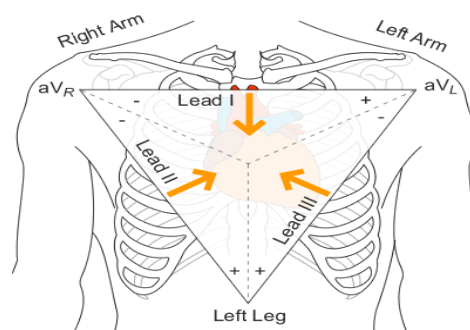
3 bipolar (standard) : L I , L II , L III

3 unipolar (augmented) : avR , avL , avF

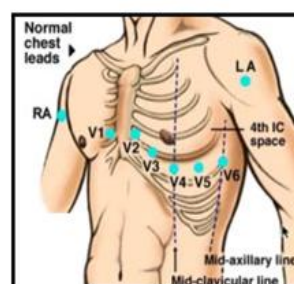
2) 6 chest (precordial) leads:

record cardiac potentials conducted in the horizontal plane .

V1 , V2 , V3 , V4 , V5 , V6



Precordial or Chest Leads



- V₁ 4th intercostal (right)
- V₂ 4th intercostal (left)
- V₃ Between V₂ & V₄
- V₄ Midclavicular (mid-collarbone)
- V₅ 5th intercostal space (anterior axillary line)
- V₆ 5th intercostal (midaxillary line)

Blood supply of the heart

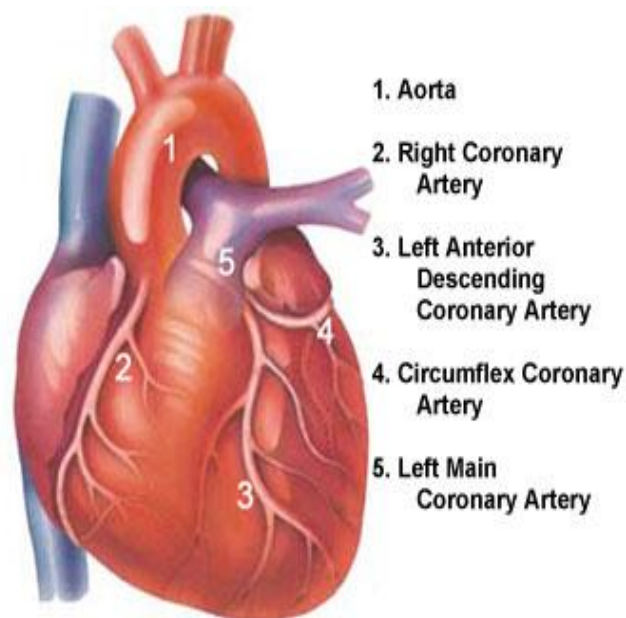
Right coronary artery : supply inferior wall .

Left coronary artery :

Ant descending : supply anterior wall

Circumflex : supply lateral wall

Each group of leads can record potentials of certain wall whose potentials are conducted parallel to these leads giving the largest portion of the wave drawn by these leads .



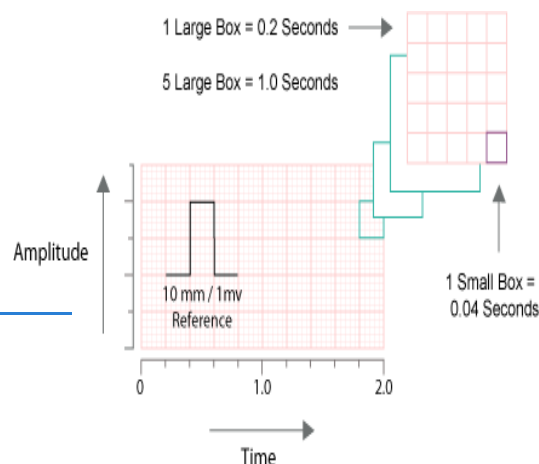
Right coronary	Inferior wall	II , III , avF
Anterior descending	Anterior wall	V 1 , 2 , 3 , 4
Circumflex	Lateral wall	V5 , V6 & avL

ECG paper:

ECG paper is a graphic divided into millimeter squares

Time is measured on the horizontal axis .

Amplitude of any wave is measured on the vertical axis in millimeters .



Horizontally

1 small square = 0.04 second

1 big square = 0.2 second

5 big square = 1 second

300 big square = 1 minute

Vertically

1 mv = 2 big squares

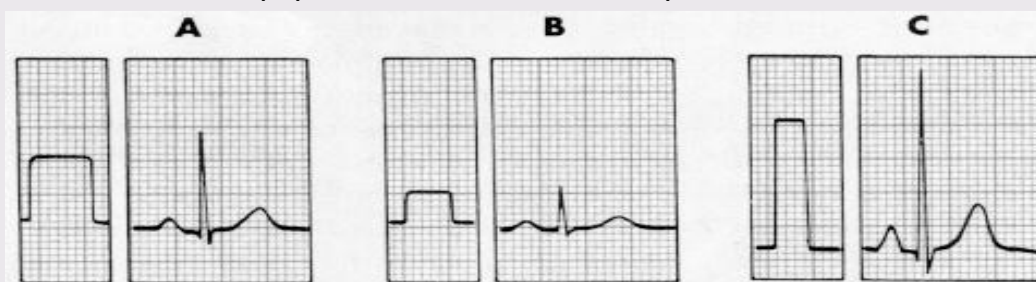
(standard calibration)

0.1 mv = 1 small square

ECG machine measures the electrical activity in millivolts .

- ECG machines are calibrated so that a recording with an amplitude of 1 mV moves the stylus vertically **10 mm** .
- The amplitude of the wave forms may be influenced by the tissue thickness, distance between leads, vector depolarization, and overall size of the heart.
- Patients with an enlarged cardiac mass due to hypertrophy have a high amplitude waveform. To prevent superimposition of waves , the whole ECG may be calibrated at **(5mm/mV . " half standardization ")**
- Patients with a pericardial effusion, emphysema, or obesity have an increased resistance to current flow and therefore a reduced amplitude . To prevent missing small waves, the whole ECG may be calibrated at **(20mm/mV . " Double standardization ")**

A): Normal standardization. (B): One-half standardization. C): Double normal standardization.



Comment on ECG:

1	2	3	4	5	6	7	8	9	10
Rhythm	Rate	Axis	P wave	PR interval	QRS	ST segment	T wave	QT interval	U wave

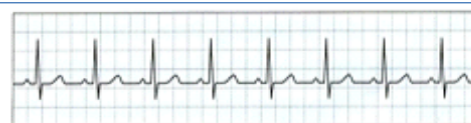
Rhythm

Regular or irregular by measuring the distance between two successive QRS

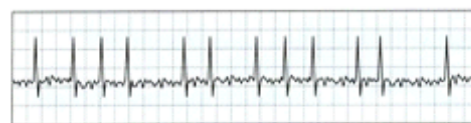
(R to R) or (S to S)

Regular : if RR intervals are uniform .

Irregular : if RR intervals are variable .



ECG tracing of a normal heart rhythm.



In atrial fibrillation, the tracing shows tiny, irregular "fibrillation" waves between heartbeats. The rhythm is irregular and erratic.

Rate

Regular :

$$\frac{300}{\text{number of large square between R - R}}$$

or
$$\frac{1500}{\text{number of small square between R - R}}$$

Irregular :

Number of R waves in 30 large square x 10

Or 300

Average number of large square between R - R

Axis deviation

For rapid determination of axis look to the direction of QRS in lead I & avF. or Lead III

Lead I				
Lead aVF				
Axis	Normal (0° to +90°)	Right (+90° to ±180°)	Left (0° to -90°)	Northwest (-90° to ±180°)

P wave :

تمثل ايه؟	Atrial depolarization
أعرفها ازاي؟	1 st +ve wave before the complex
أحسن مكان	L II, V1
مقاساتها	$2\frac{1}{2} \times 2\frac{1}{2}$ small squares

PR interval:

بداية وبداية

Represents AVN conduction .

Start from the beginning of P wave to the beginning of QRS
normally 3 – 5 small square

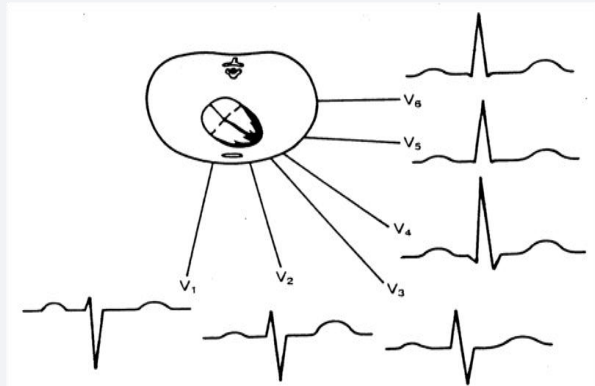
NB: PR segment : نهاية وبداية

QRS complex:

تمثل ايه؟	Vent. Depolarization
أعرفها ازاي؟	Complex
أحسن مكان	V1-V2 & V5-V6
مقاساتها	Q: 1 st -ve wave in the complex عرضها: مقاساتها: < 1 small square عمقها: $< \frac{1}{4}$ the next R
	R: the only +ve in the complex عرضها: مقاساتها: 2-3 small square ارتفاعها: 1-5 big square

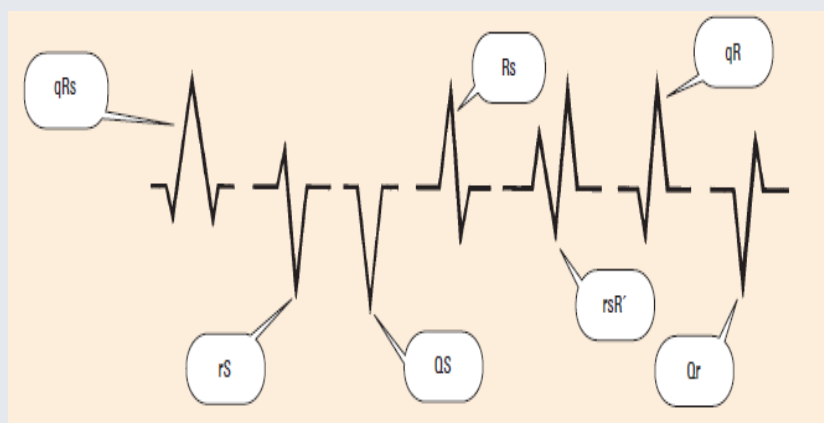
NB:

From V 1 to V 6 there is normal progression of R wave and normal regression of S waves in chest leads.

**NB:**

Not every QRS contain Q & R & S but it may be

- Monophasic: (R or QS)
- Biphasic: (RS or QR)
- Triphasic: (QRS or RSR[^])



ST segment : نهاية وبداية	Represents end of ventricular depolarization and the beginning of ventricular recovery or repolarization . The point that marks the end of the QRS complex and the beginning of the ST segment is known as the J point Ends by merging smoothly to T wave . Isoelectrical line as P- R
T wave : (Never absent)	Represents ventricular repolarization . Less than 6 small square in width . Less than 1 / 3 R in height . Usually assymetrical in shape .
QT interval: بداية ونهاية	measures ventricular depolarization and repolarization. The length of the QT interval varies according to heart rate. The faster the heart rate, the shorter the QT interval extends from the beginning of the QRS complex to the end of the T wave
U wave	Represents the recovery period of the Purkinje or ventricular conduction fibers. It isn't present on every rhythm strip. When present, a normal U wave has the following characteristics : • location : follows the T wave • configuration : typically upright and rounded • deflection : upright. The U wave may not appear on an ECG. A prominent U wave may be due to hypercalcemia, hypokalemia, or digoxin toxicity

Abnormal ECG

Bundle branch block (BBB)

QRS complex width > 2.5 mm

2.5 – 3 mm : incomplete block

> 3 mm : complete block

Left bundle branch block:

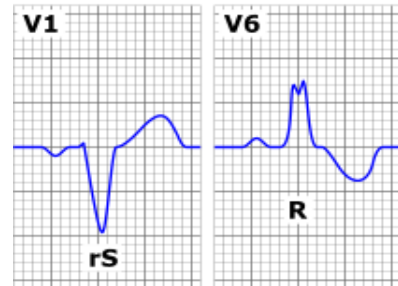
QRS shape : in V5 , V6 & I : monophasic notched R

In V1 & V2 : QS pattern or rS pattern

T wave : secondary inversion in V5 & V6



Left bundle branch block characteristics



Right bundle branch block:

QRS shape : in V1 & V2 rSR with wide R (2 positive)

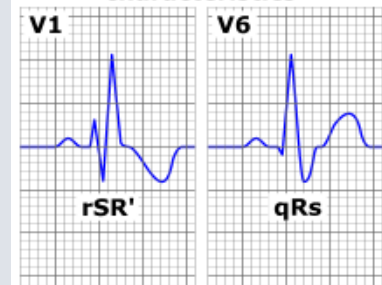
or RR monophasic notched tall R (M shaped R)

In V5 , V6 & I : qRS with large slurred S

T wave : secondary inversion in V1 & V2



Right bundle branch block characteristics



In RBBB don't diagnose:
Myocardial ischemia .
Ventricular enlargement

In LBBB don't diagnose:
Myocardial ischemia.
Myocardial infarction.
Ventricular enlargement.
Hemiblock.

Atrial enlargement

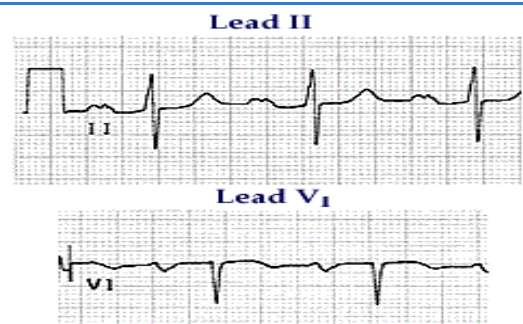
1) Left atrial enlargement:

Lead II:

P- **Mitrale**: P wave is broad (> 2.5 mm) and bifid

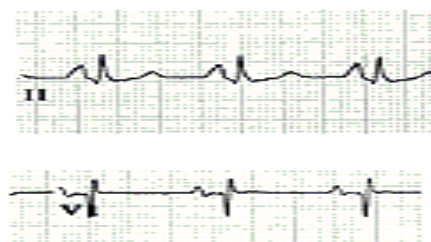
Lead V 1:

Negative deflection of P is broad & deep $> 1 \times 1$ mm.



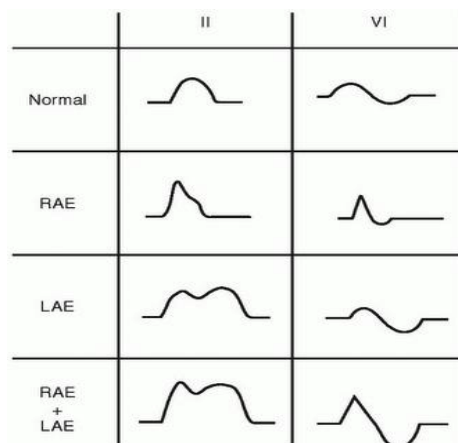
2) Right atrial enlargement:

Lead II: P **Pulmonale** : Tall > 2.5 mm & peaked
 Lead V1: **positive deflection of P** is tall > 1.5 mm



3) Biatrial enlargement:

Lead II : P **pulmonale - mitrale**.
 Lead V1 : Positive deflection of P is tall
 Negative deflection of P is broad.



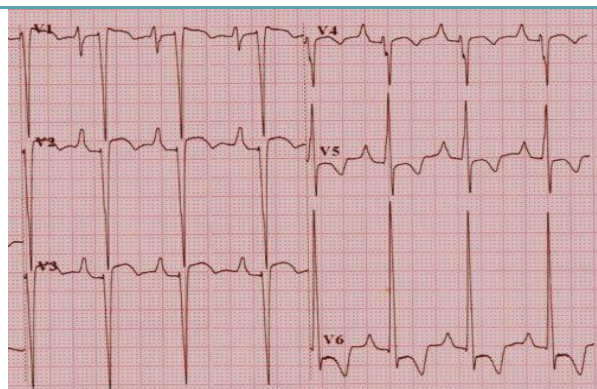
Ventricular enlargement

1) Left ventricular enlargement:

Exaggeration of normal

Deep **S** in V1 or V2 > 5 big square (> 25 mm)
 Or Tall **R** in V5 or V6 > 5 big square (> 25 mm)
 or $S_{1-2} + R_{5-6} \geq 7$

+/- **Strain** ischemia : ST depression and/or inverted T
 , may be present in V5 & V6 due to pressure overload .
 ± LAD

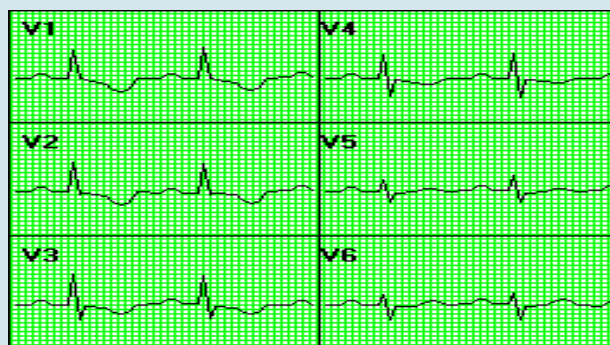


2) Right ventricular enlargement

Reversal of normal

Tall **R** in V1 or V2 - $R > S$
 or Deep **S** in V5 or V6 - $S > R$

+/- **Strain** ischemia : ST depression and/or inverted T
 may be present in V1 & V2 due to pressure overload
 ± RAD



Myocardial Ischemia

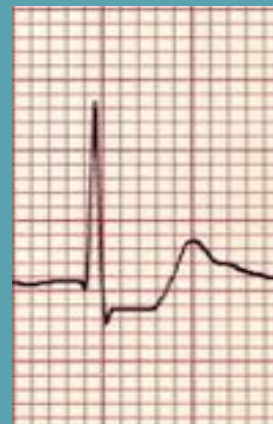
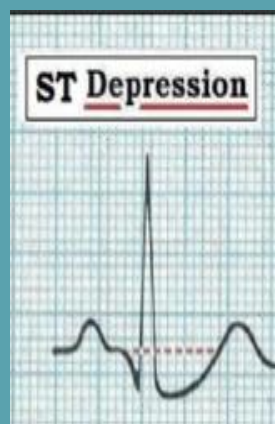
ECG changes :

ST segment depression from base line with depressed J point

Or T wave flat or inverted .

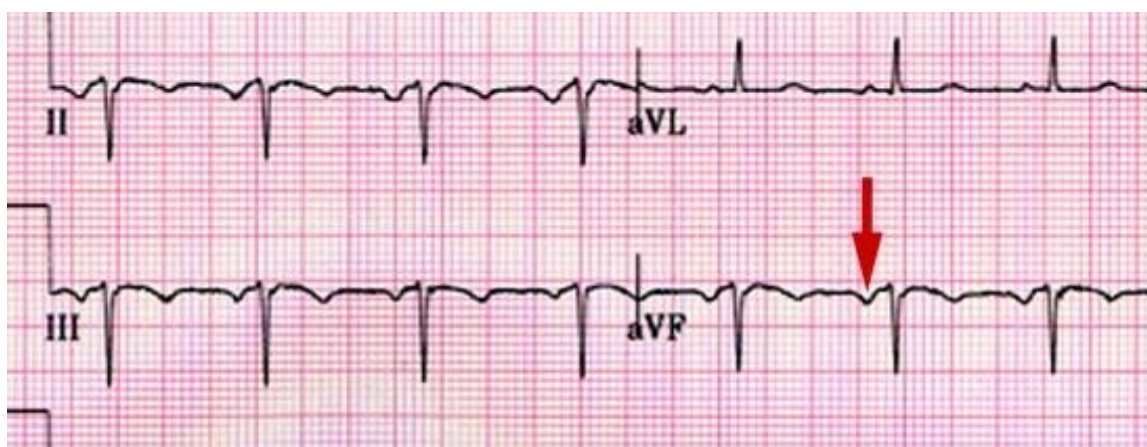
* Define site according to **topographism** .

Present in at least two leads of the same wall .



In this ECG there is T wave inversion

in lead II , III and avF indicating inferior wall myocardial ischemia .



Myocardial infarction

ECG changes:

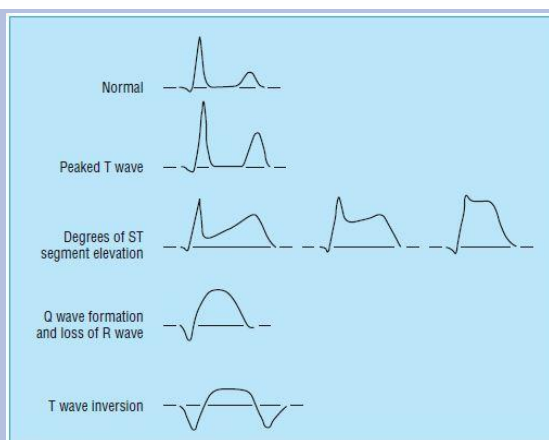
Hyperacute T wave :

(tall , narrow , symmetrical & peaked)

ST segment elevation above base line .

Pathological Q : > 1 small square in width
, > 25 % of the following R .

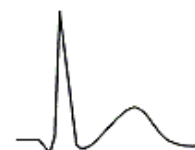
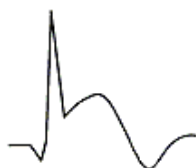
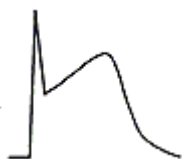
* These changes are seen in at least two leads in the same wall.



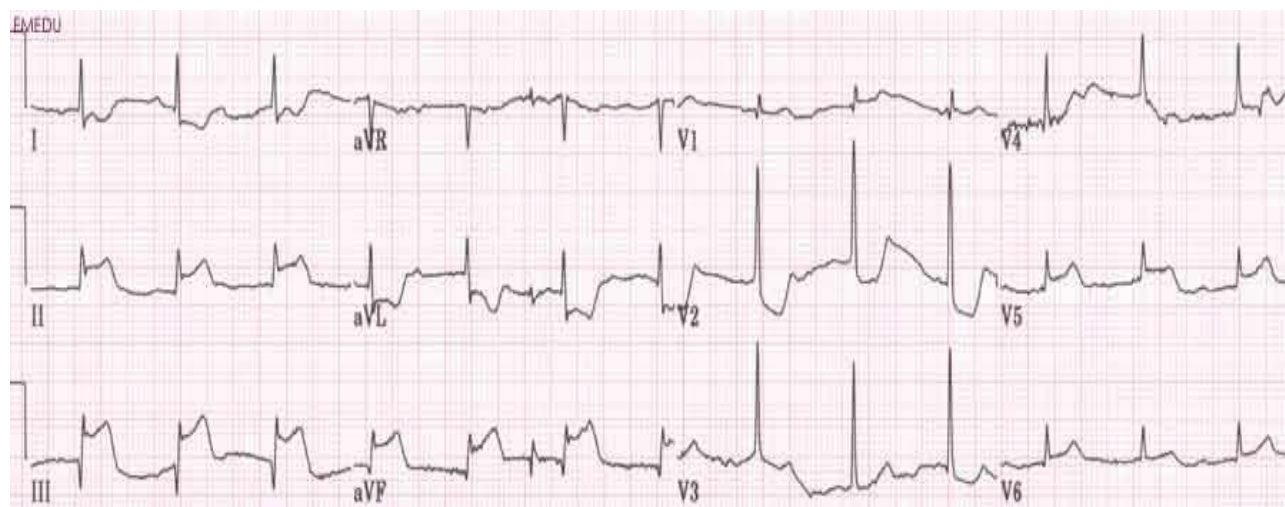
Sequence of changes seen during evolution of myocardial infarction

Age of MI:

Recent hyper acute MI	Acute MI	Old MI
ST segment elevation +/- hyper acute T wave . No pathological Q .	ST elevation convex then descending to base line. Pathological Q	Pathological Q . ST & T wave are normal <i>NB : persistent elevation of ST segment occur in aneurysm .</i>

**In this ECG:**

ST elevation in lead II , III & aVF indicating acute inferior wall MI



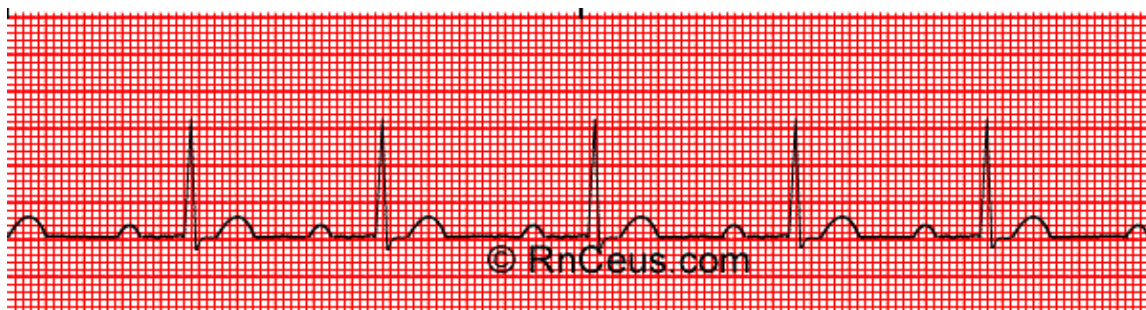
Scheme for any segmented ECG

P wave	Tall & Peaked	=	Right atrial enlargement
	Broad	=	Left atrial enlargement
QRS	V1,2		V5,6
	A) shape (M shaped)	Right BBB	Left BBB
	B) Direction	R > S = Rt.v. +++ or	S > R = Rt. V. +++
	C) voltage	S > 5 big square or Lt.v.+++	R > 5 big square = Lt.v. ++
	ST segment:	Elevated :	
	In all leads:	Pericarditis	
	with <u>topographism</u> :	recent MI	
	Depressed :		
	All leads:	(sagging) digitalis effect .	
	with <u>topographism</u> :	ischemia .	
Pathological Q	With <u>topographism</u> :	old MI	
Tall T	In all leads	=	hyperkalemia.

Heart block

1st degree AV block

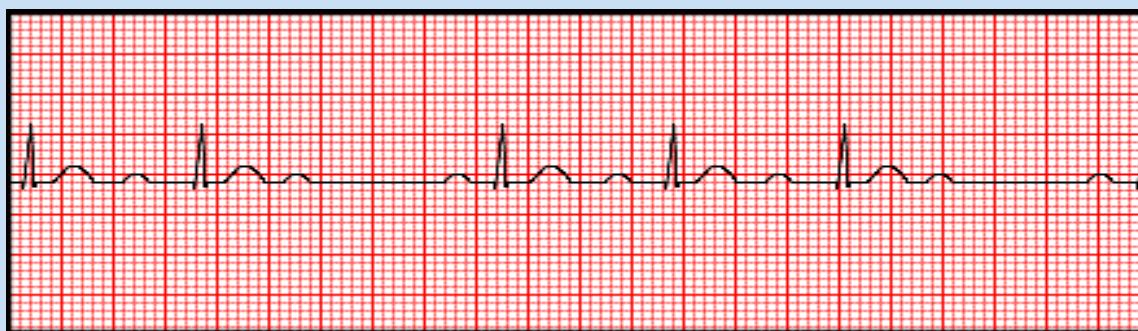
Prolonged PR interval more than 5 small square .



2nd degree AV block

Mobitz type 1 (Wenckebach)

Progressive prolongation of P-R intervals until dropped QRS .



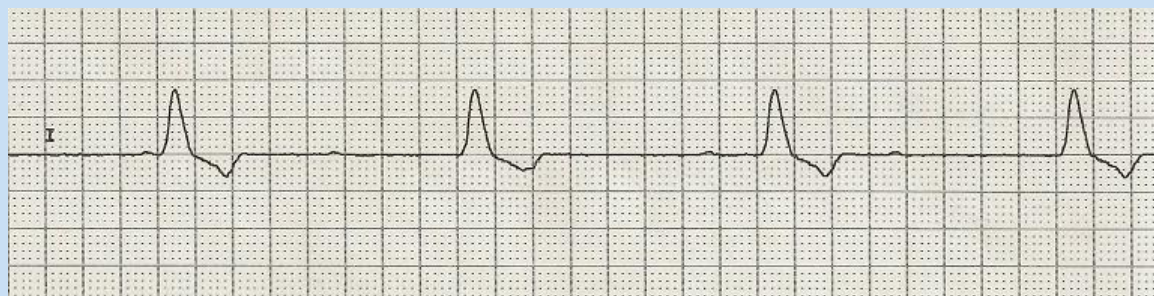
Mobitz type 2

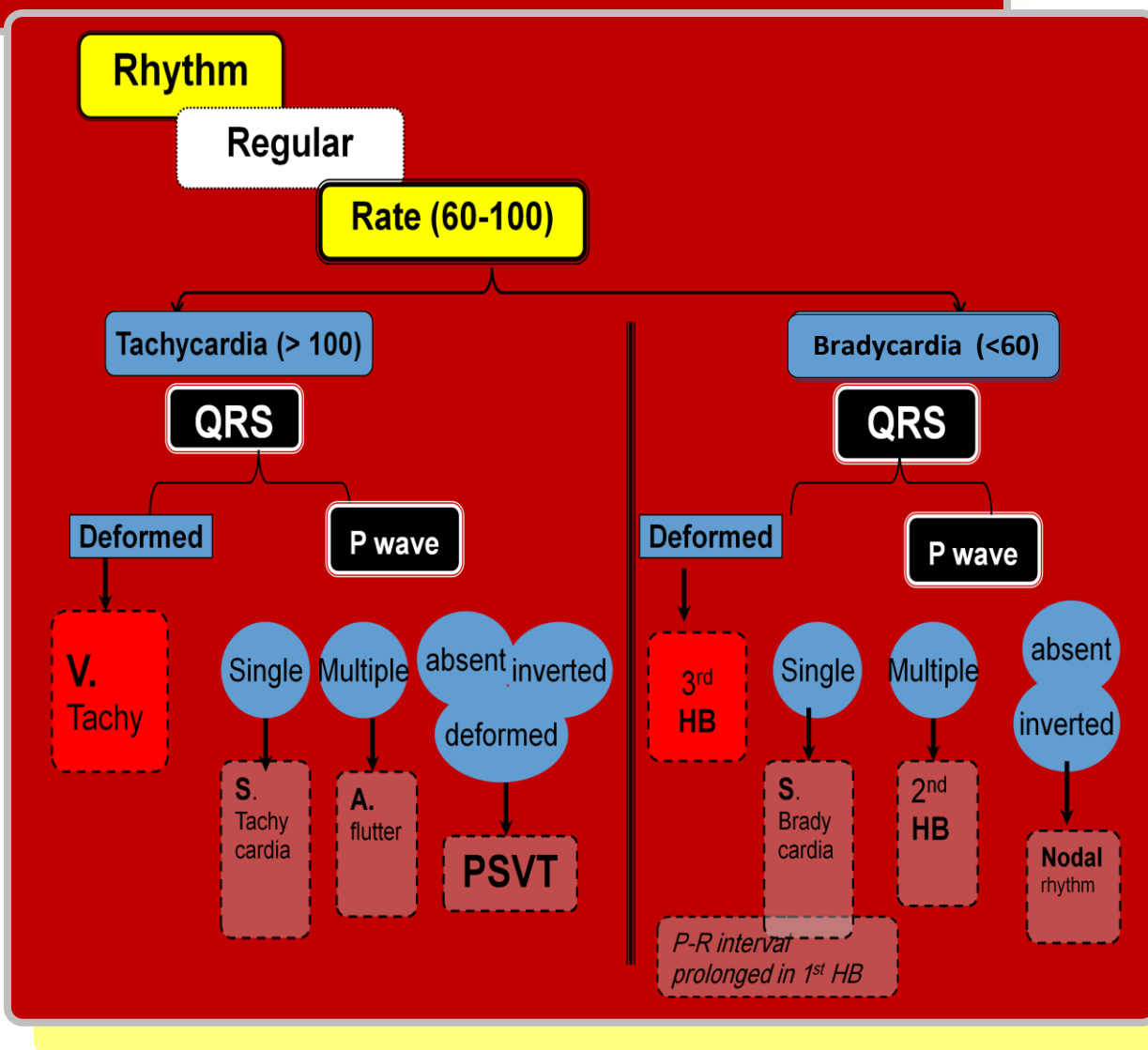
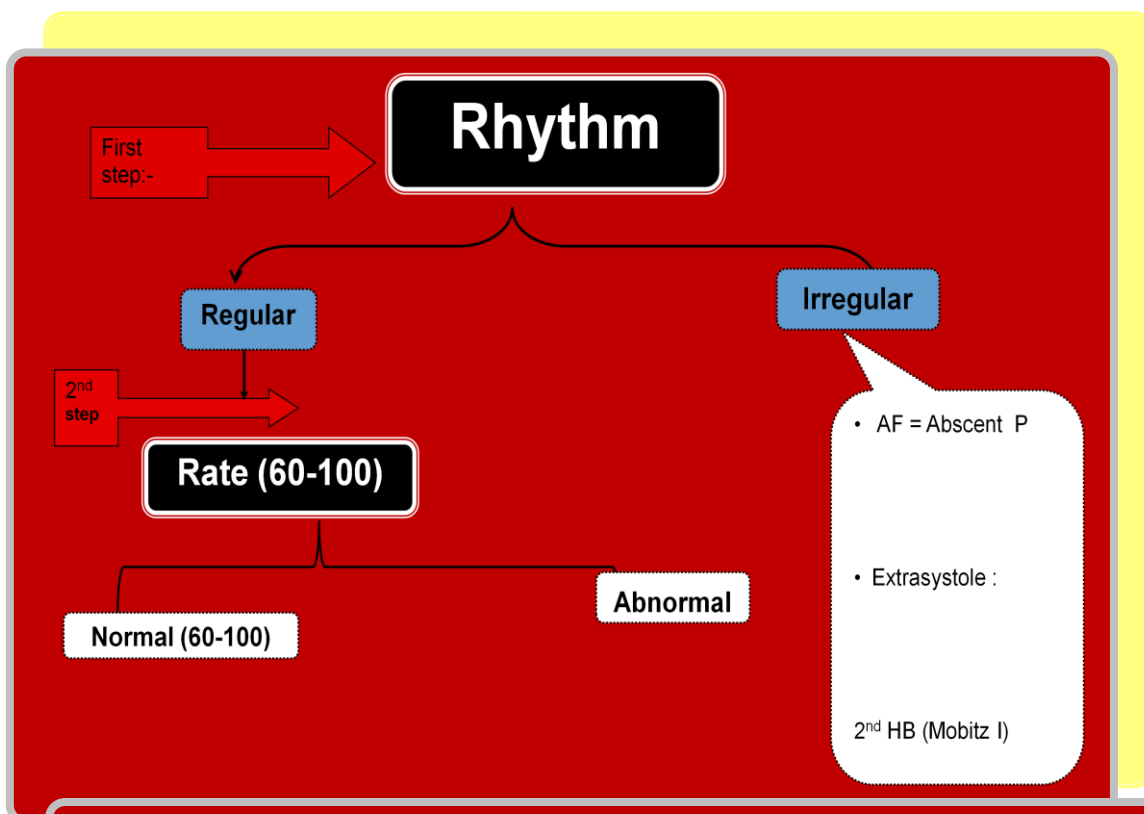
regular drop of QRS .

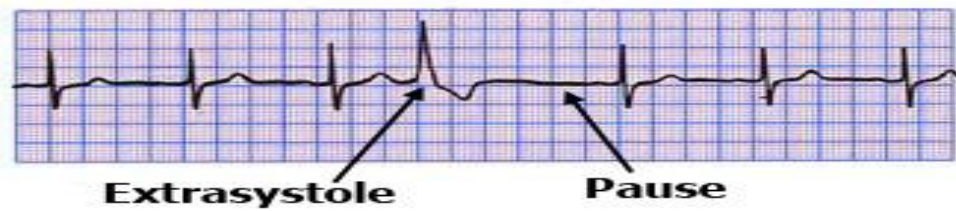
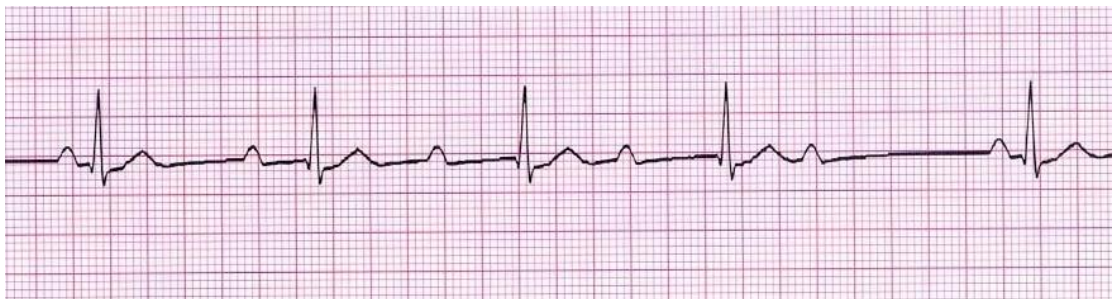


3rd degree AV block

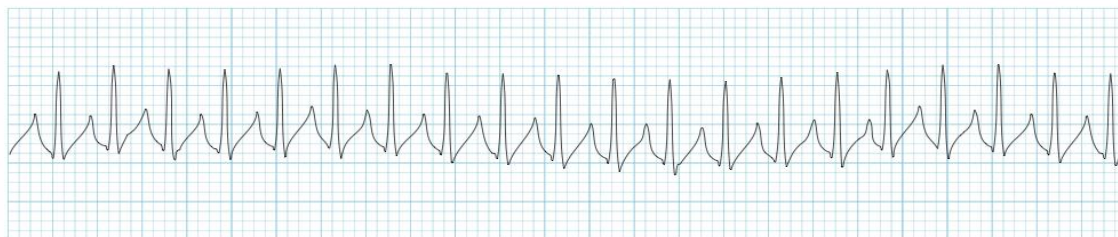
A.V dissociation





Irregular rhythm:**Atrial fibrillation****Absent P wave****Fibrillatory waves may be coarse or fine .****Extra systole****Ventricular Extrasystole****Mobitz type 1**

Regular rhythm

Tachycardia : > 100 **1st :-** If QRS is deformed (Broad & bizarre) : Ventricular tachycardia .**2nd :-** If QRS is narrow and normal :Look at P wave**Single****Sinus tachycardia****Multiple****Atrial flutter****Absent or inverted****Supraventricular tachycardia (AVN)****Deformed****Supraventricular tachycardia (atrial)**

Bradycardia : < 60

1st :-If QRS is deformed (Broad & bizarre) : 3rd degree heart block



2nd :-If QRS is narrow , normal

look at P Wave :

Single

Sinus bradychardia



Multiple

Mobitz type 2



Absent or inverted

Nodal rhythm



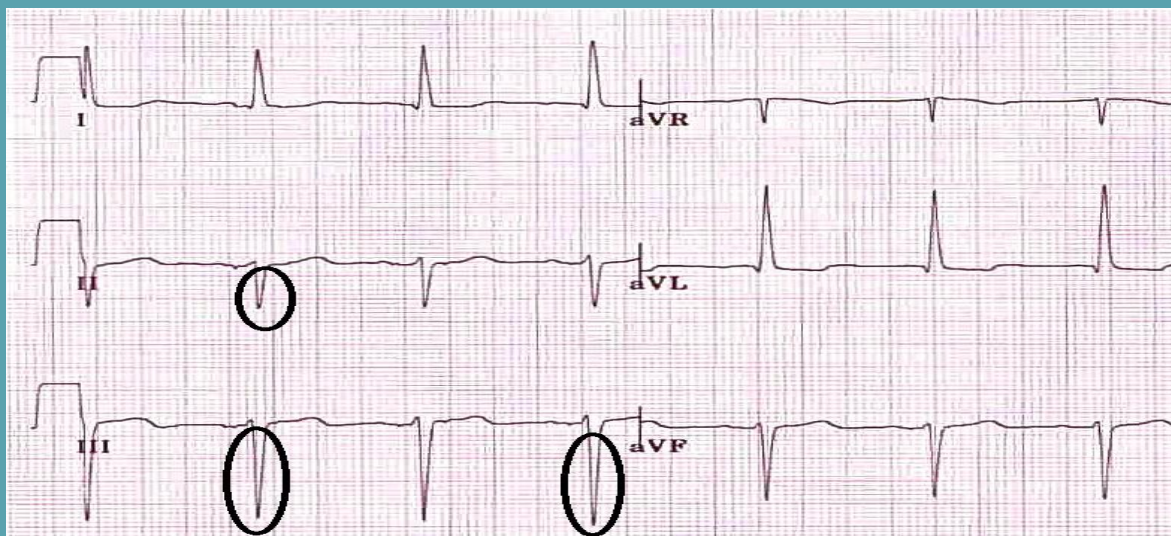
Miscellaneous

Other advanced ECG:

Hemi-block

Left anterior hemi-block :

Left axis deviation + **deep S (R / S ratio < 1) in II , III , aVF**



Left posterior hemi-block :

Right axis deviation + **deep S in lead I & aVL**



Bi-fascicular block : right bundle branch block + hemi-block

Tri-fascicular block : Bi-fascicular block + 1st degree AV block

Wolf Parkinson white syndrome

Short PR interval < 3 small square
wide QRS
Delta wave (initial slowing of QRS)



Multifocal atrial tachycardia
in cases of chronic hypoxia
e.g : COPD

Irregular rhythm
tachycardia
≥ 3 different shapes of P wave



Wandering atrial pacemaker
in cases of sick sinus syndrome .

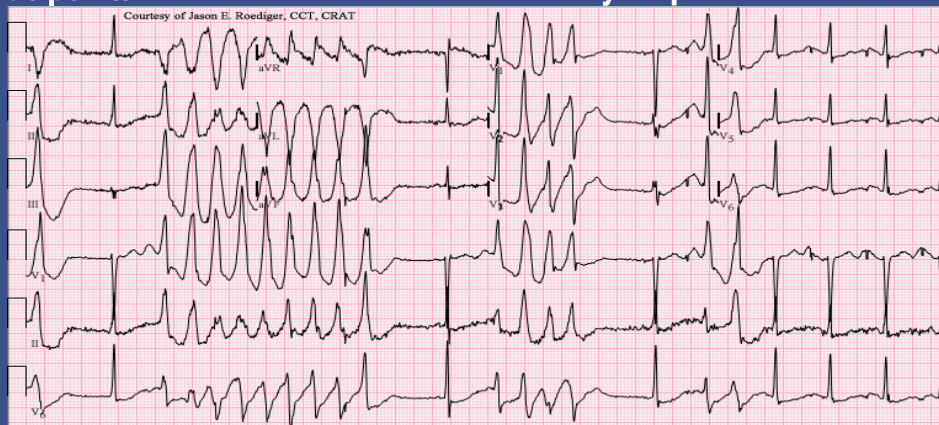
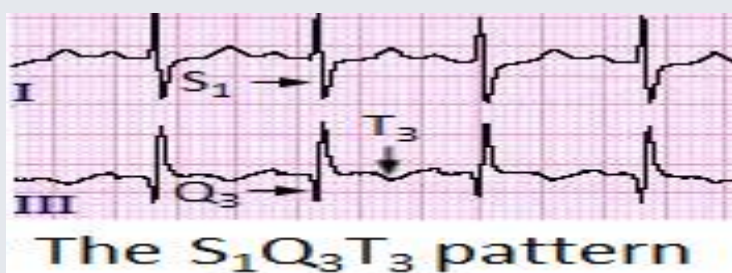
Irregular rhythm
normal rate
≥ 3 different P waves .



Accelerated idioventricular rhythm :
The commonest reperfusion arrhythmia

Regular rhythm .
Rate : 40 – 100
Absent P wave
wide QRS



Torsade de points**Polymorphic ventricular tachycardia .****Pulmonary embolism****Deep S in lead I****Pathological Q & inverted T in lead III****Hyperkalemia**

Hyperacute T wave

(In all leads) .

Prolonged PR interval

wide QRS

Lost P wave

sine wave pattern

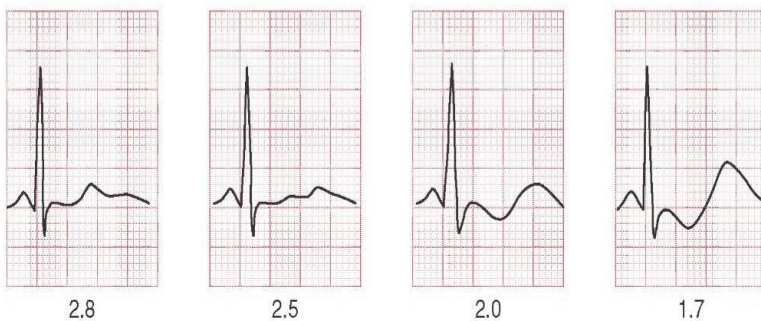
Asystole .

**Hyperkalemia****Hypokalemia :**

ST depression .

Prominent U wave .

Long QT .

**Hypokalemia**

Hypercalcemia
short QT interval



Hypocalcemia
Long QT interval .



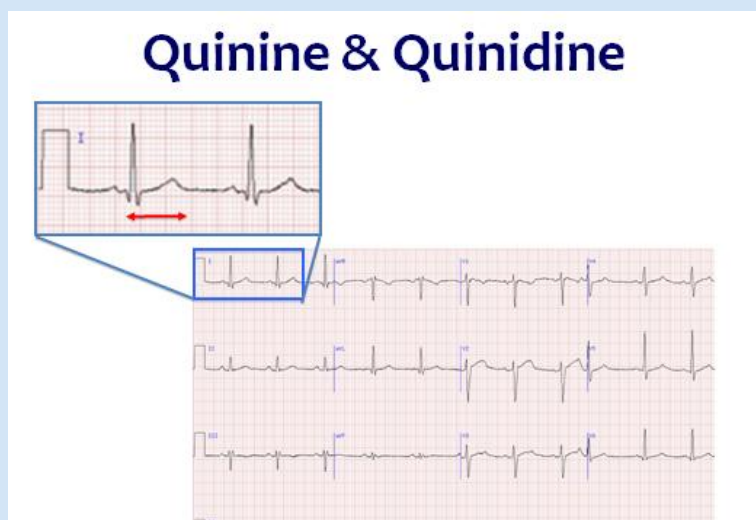
Digitalis effect

- 1) Sagging ST - T
ST depression with isoelectrical J point .
T wave inversion .
Fused ST & T
- 2) short QT interval



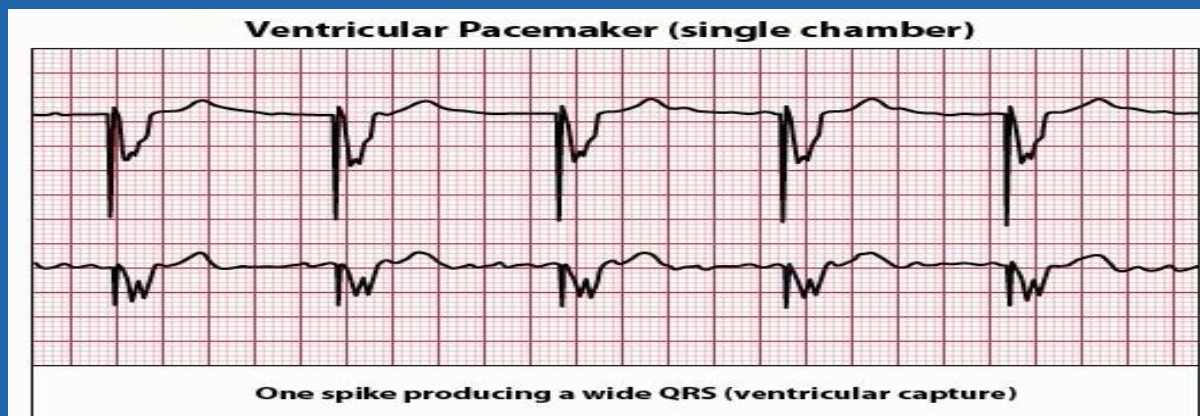
Quinidine . Procainamide effect

- Long QT interval .
- Flat T wave .
- Wide QRS .
- Prominent U wave



Pacemaker pattern (spike)

Ventricular pacemaker :
Spike precede each QRS .

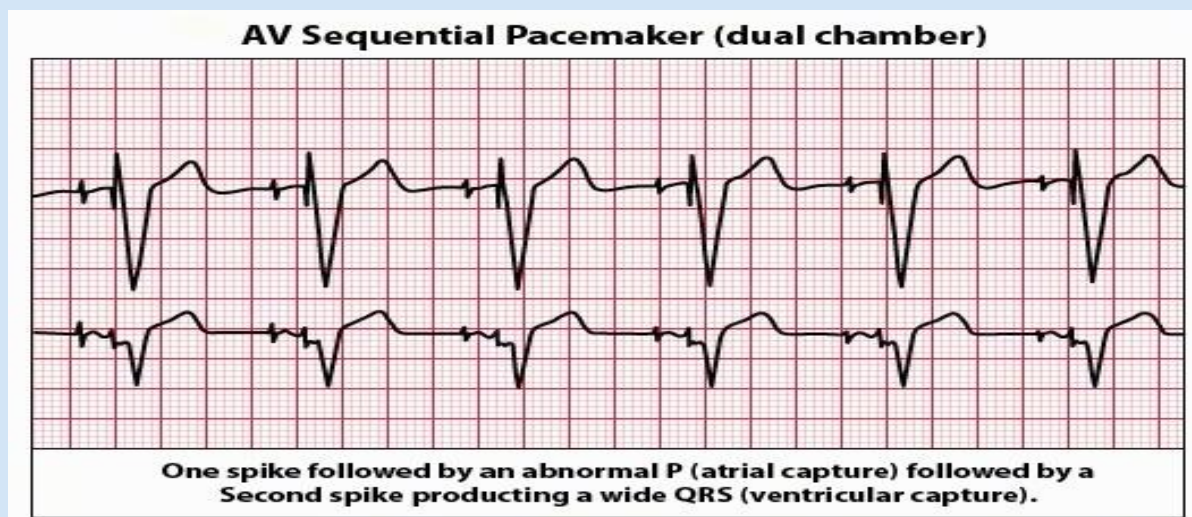


Dual chamber pacemaker (AV sequential pacemaker) :

Two spikes :

One spike before each QRS .

Another spike seen before P wave .

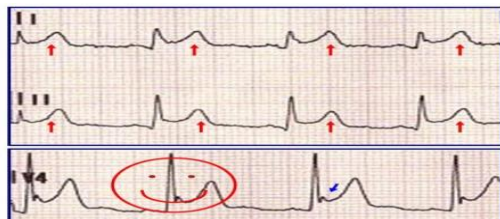


NB : if Pacemaker spike is not followed by a complex , this means failure of pacing
= Pacemaker malfunction ☹

Differential diagnosis of:**ST segment elevation**

Recent Myocardial infarction :
In some leads , convex upwards ,
pathological Q

Pericarditis :
In all leads , concave upwards ,
Absent pathological Q



Variant angina :
In some leads , flat ,
Absent pathological Q .

Old MI + Aneurysm
(Persistent elevation)

Depressed ST segment

Ischemia :
In some leads

Hypokalemia :
In all leads .

Strain pattern of ventricular hypertrophy

Sagging depression in digitalis effect
(iso-electrical J point)

Flat or inverted T

Ischemia :
In some leads .

Hypokalemia :
In all leads .

Strain pattern of ventricular hypertrophy .

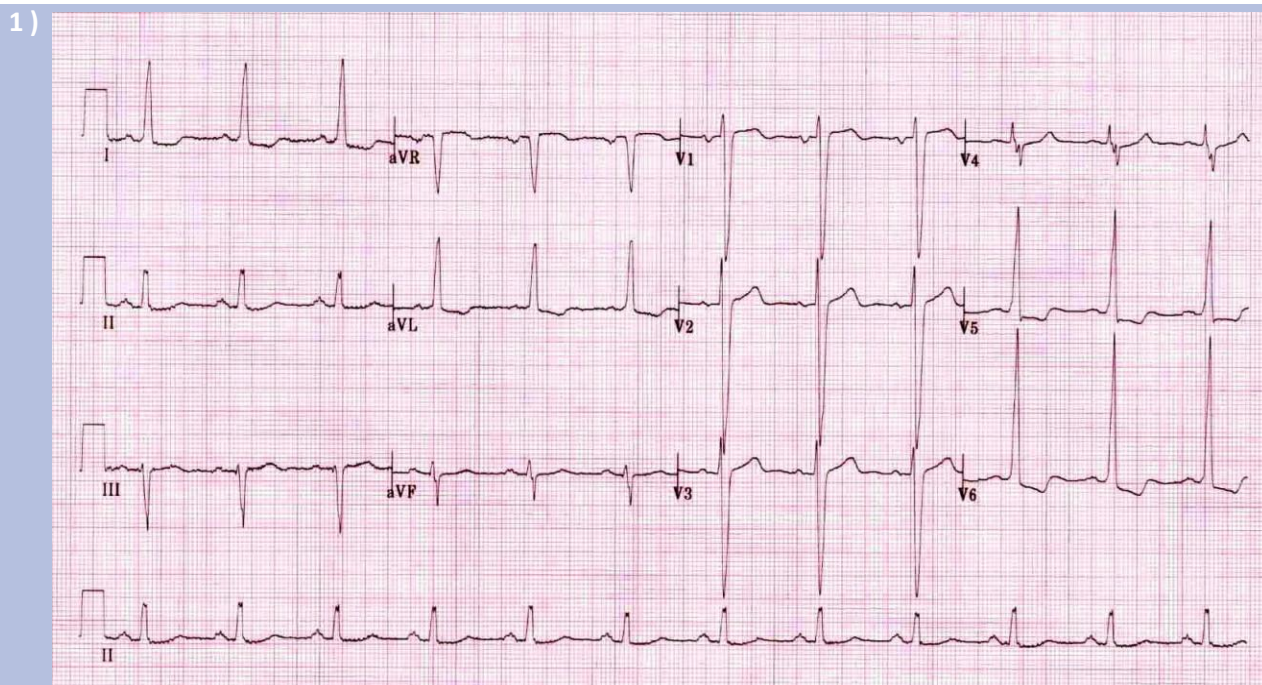
Bundle branch block .

Hyperacute T wave :

Acute MI :
In some leads .

Hyperkalemia :
in all leads

ECG examples :



1)

Rhythm : regular

Rate : 75 b / minute

Axis: Lt. AD

P wave: normal.

PR interval : normal

QRS :

tall R in V6 > 5 small square

tall S in v1,2 > 5 small square

ST segment : depression in V5, 6

T wave : normal

Diagnosis : **Left ventricular hypertrophy**
With strain ischemia.

2)

Rhythm: regular.

Rate : 35 b / minute

P wave : normal

PR interval : normal

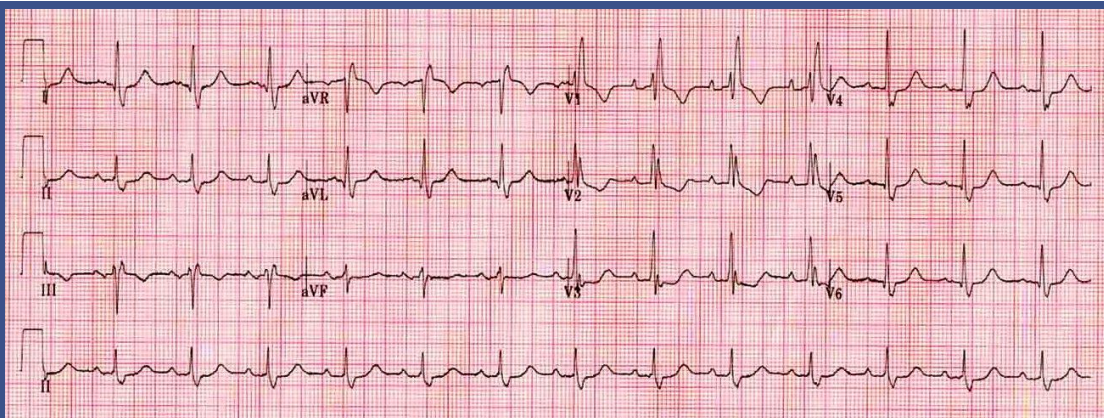
QRS : normal

T wave : normal

Diagnosis :

Sinus Bradycardia

3)



4)



5)



3)

Rhythm : regular

Rate : 85 b / minute

Axis : Lt.AD

P wave : normal

PR interval : normal

QRS : deformed in V1 , 2
(rSR)

ST segment : normal

T wave : normal

Diagnosis :

Right bundle branch block

4)

Rhythm : regular

Rate : 115 b / minute

P wave : normal

PR interval : normal

QRS : normal

T wave : normal

Diagnosis :

Sinus tachycardia

5)

Rhythm ; regular

Rate : 50 b / minute

P wave : inverted

PR interval :

QRS : normal

T wave : normal

Diagnosis :

Nodal rhythm

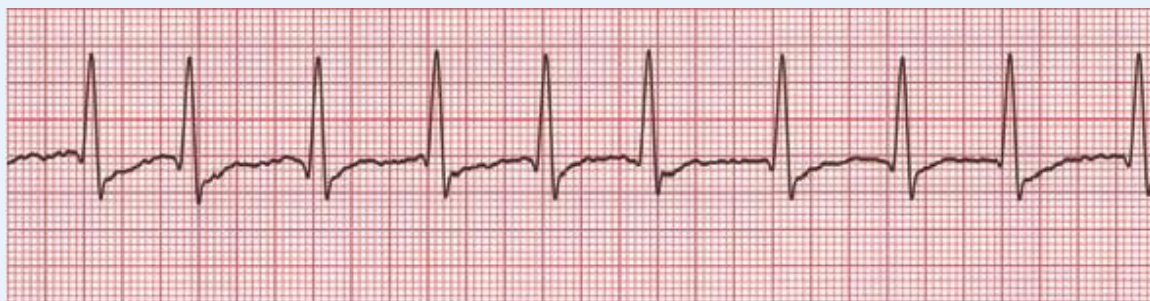
6)



7)



8)



6)

Rhythm : regular
 Rate : 85 / minute
 Axis : Rt. AD
 P wave : tall & peaked in lead II
 (P pulmonale)
 PR interval : normal
 QRS : Tall S in V5 (S > R)
 ST segment : normal
 T wave : inverted in lead III ,
 aVF & V 1,2 ,3, 4
 Diagnosis :
 Right atrial dilatation
 Right ventricular enlargement
 Anteroinferior ischemia

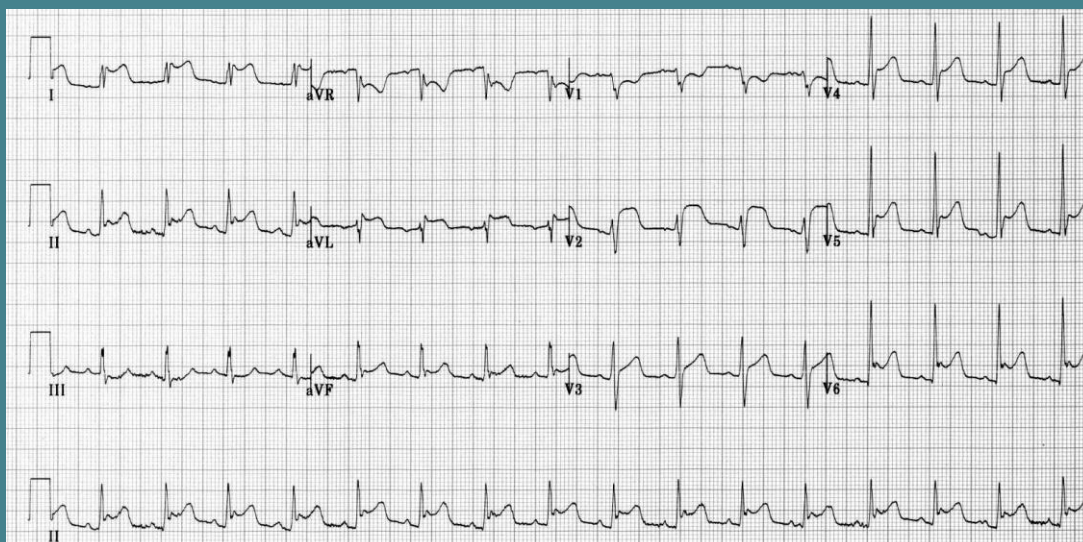
7)

Rhythm : regular
 Rate : 42 b / minute
 P wave : normal & multiple
 PR interval : normal
 QRS : normal
 T wave : normal
 Diagnosis :
 2nd degree AV block
 (Mobitz type 2)

8)

Rhythm : irregular
 Rate : 100 b / minute
 P wave : absent
 PR interval : ☺
 QRS : normal
 Diagnosis :
 Atrial fibrillation

9)



10)



11)



9)

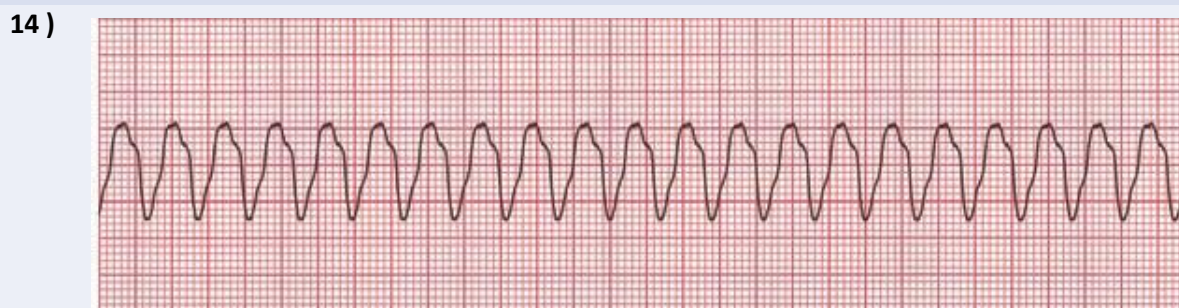
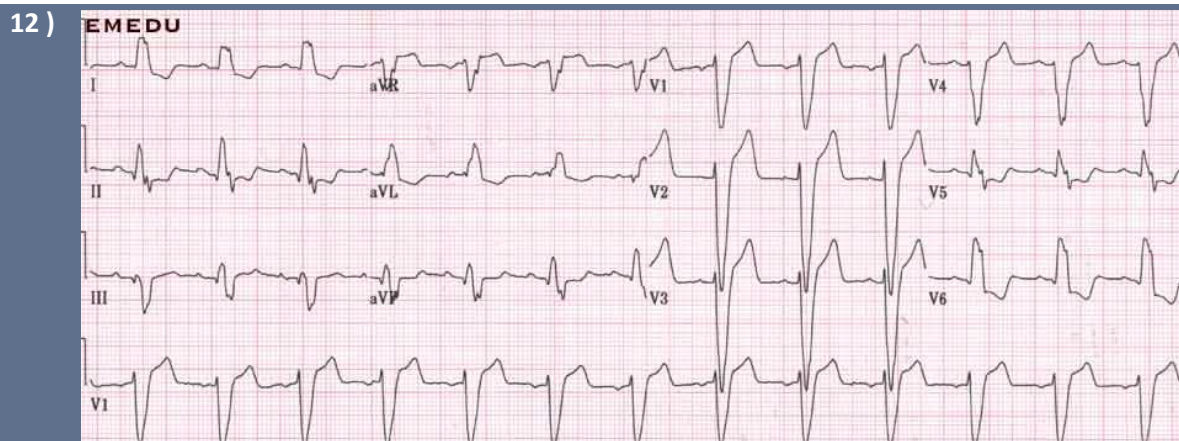
Rhythm : regular
 Rate : 100 b / minute
 Axis : normal
 P wave : normal
 PR interval : normal
 QRS : normal
 ST segment :
 Diffuse elevation in lead I , II , III ,
 aVF , V 2 , 3 , 4 , 5
 T wave : normal
 Diagnosis :
 (Pericarditis)

10)

Rhythm : irregular
 Rate : 170 b / minute
 P wave : none
 PR interval : none
 QRS : Broad , bizarre &
 polymorphic
 Diagnosis :
 (Torsade de pointes)

11)

Rhythm : irregular
 Rate : 65 b / minute
 P wave : normal
 PR interval : variable
 QRS : normal
 Diagnosis :
 2nd degree AV block
 (Mobitz type 1)

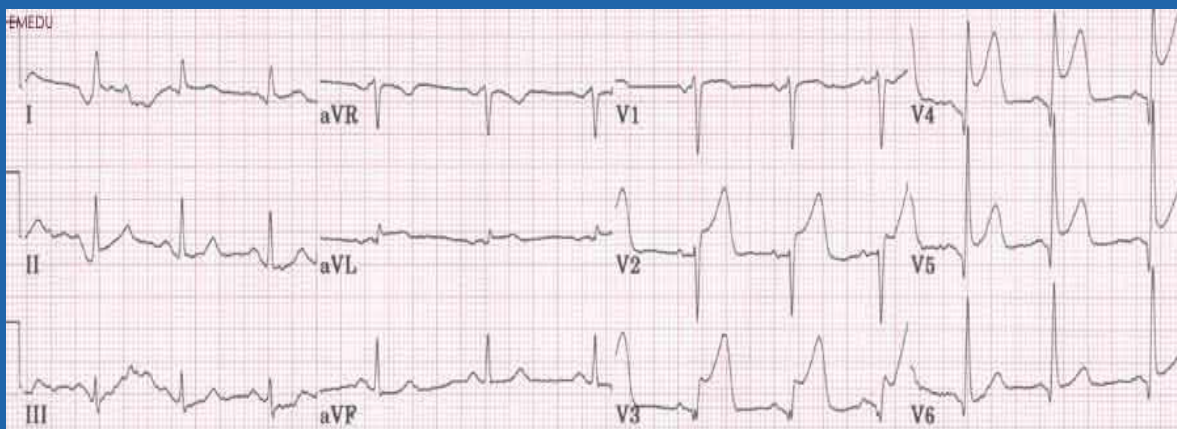


12)
 Rhythm : regular
 Rate : 100 b / minute
 Axis : Lt AD
 P wave : normal
 PR interval : normal
 QRS : wide
 rS pattern in V1
 notched R in V 5 , 6 & I
 ST segment : normal
 T wave : secondary inverted in V6
 Diagnosis : **Left bundle branch block**

13)
 Rhythm : irregular
 Rate : 130 b / minute
 P wave : absent
 PR interval : ☺
 QRS : normal
 Diagnosis :
Atrial fibrillation

14)
 Rhythm : regular
 Rate : 214 b / minute
 P wave : absent
 PR interval : ☺
 QRS : broad & bizarre
 Diagnosis :
Ventricular tachycardia

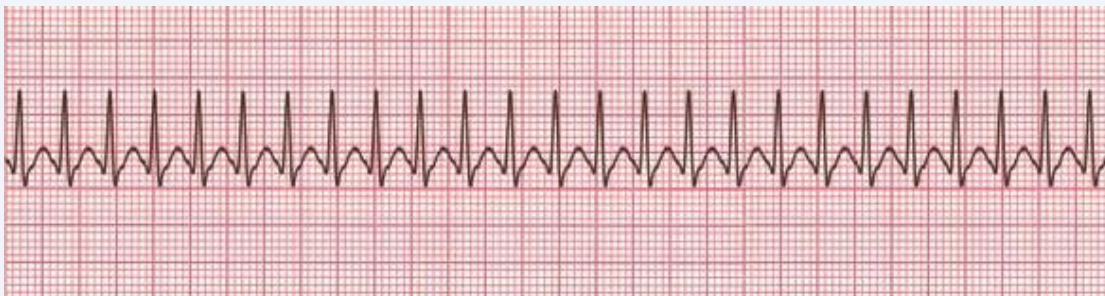
15)



16)



17)



15)

Rhythm : regular
 Rate : 65 b / minute
 Axis : normal
 P wave : normal
 PR interval : normal
 QRS : normal
 ST segment :
 Elevated in V 2 , 3 , 4 , 5
 T wave :
 Hyperacute in V 2 , 3 , 4 , 5
 Diagnosis :
 Acute anterior MI

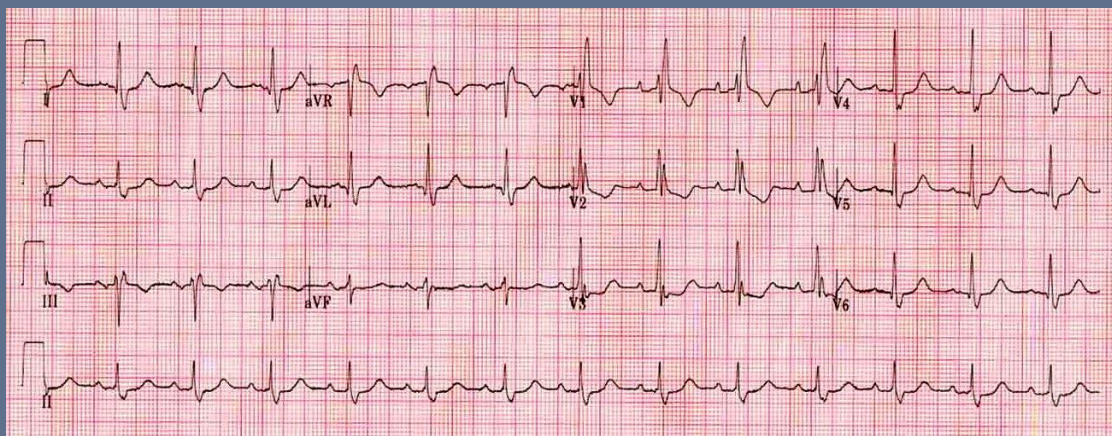
16)

Rhythm : regular
 Rate : 75 b / minute
 P wave : normal
 PR interval : normal
 QRS : normal
 Diagnosis :
 Normal sinus rhythm

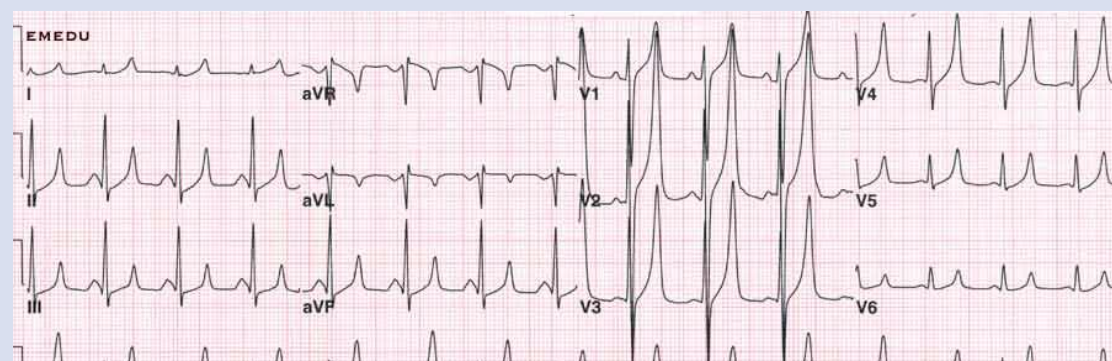
17)

Rhythm : regular
 Rate : 250 / minute
 P wave : absent
 PR interval : ☺
 QRS : normal
 Diagnosis :
 **Supraventricular tachycardia
 (Junctional)**

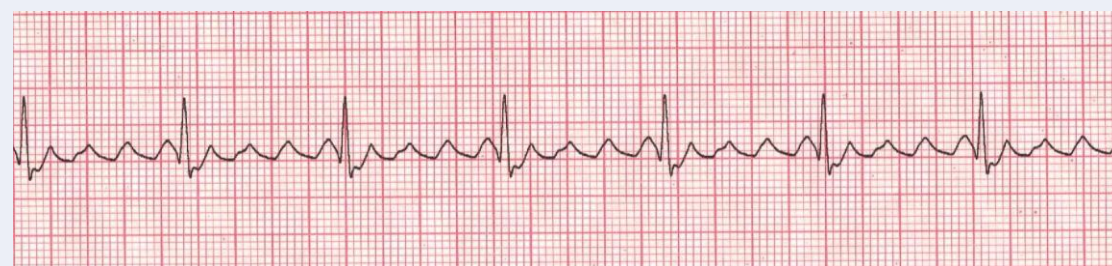
18)



19)



20)



18)

Rhythm : regular
 Rate : 100 / minute
 Axis : left
 P wave : normal
 PR interval : normal
 QRS : rSR in lead V1
 Large slurred S in V5,6 & I
 ST segment : normal
 T wave : inverted in V1 , 2
 Diagnosis :
 (Right bundle branch block)

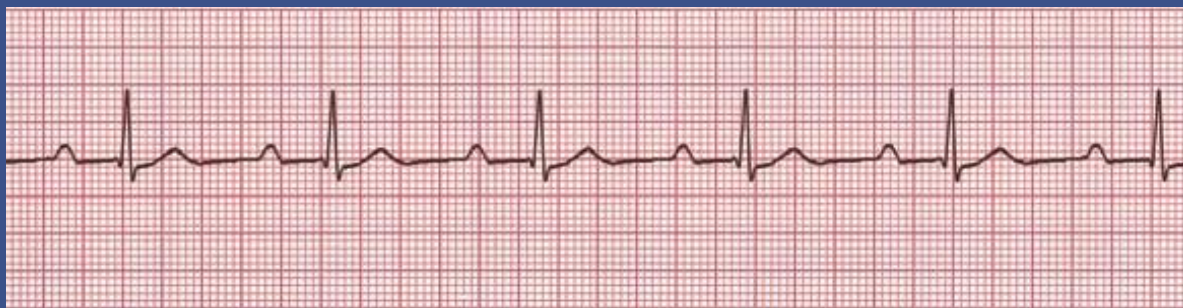
19)

Rhythm : regular
 Rate : 100 / minute
 Axis : normal
 P wave : normal
 PR interval : normal
 QRS : normal
 ST segment : normal
 T wave : hyperacute
 (Himalaya T) in all leads
 Diagnosis :
 (Hyperkalemia)

20)

Rhythm : regular
 Rate : 65 / minute
 P wave : absent
 Replaced by flutter waves
 PR interval : ☺
 QRS : normal
 Diagnosis :
 Atrial flutter

21)



22)



23)



21)

Rhythm : regular
 Rate : 58 / minute
 P wave : normal
 PR interval : prolonged
 QRS : normal
 Diagnosis : **1st degree AV block**

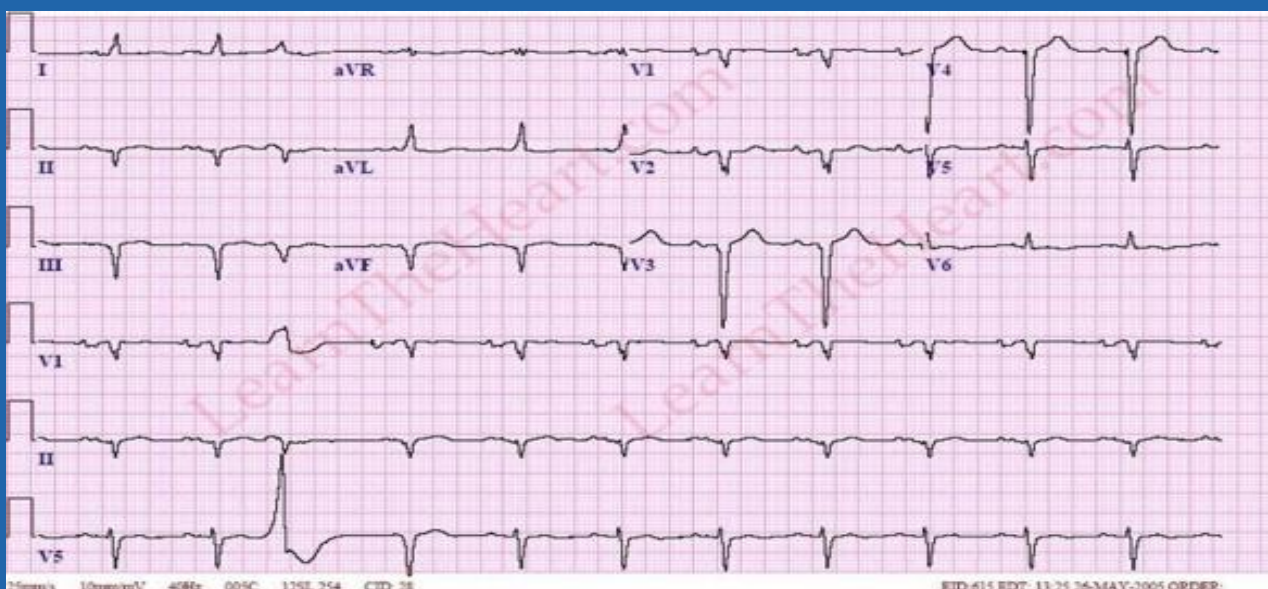
22)

Rhythm : regular
 Rate : 48 b / minute
 P wave : inverted
 PR interval : normal
 QRS : normal
 Diagnosis : **Nodal rhythm**

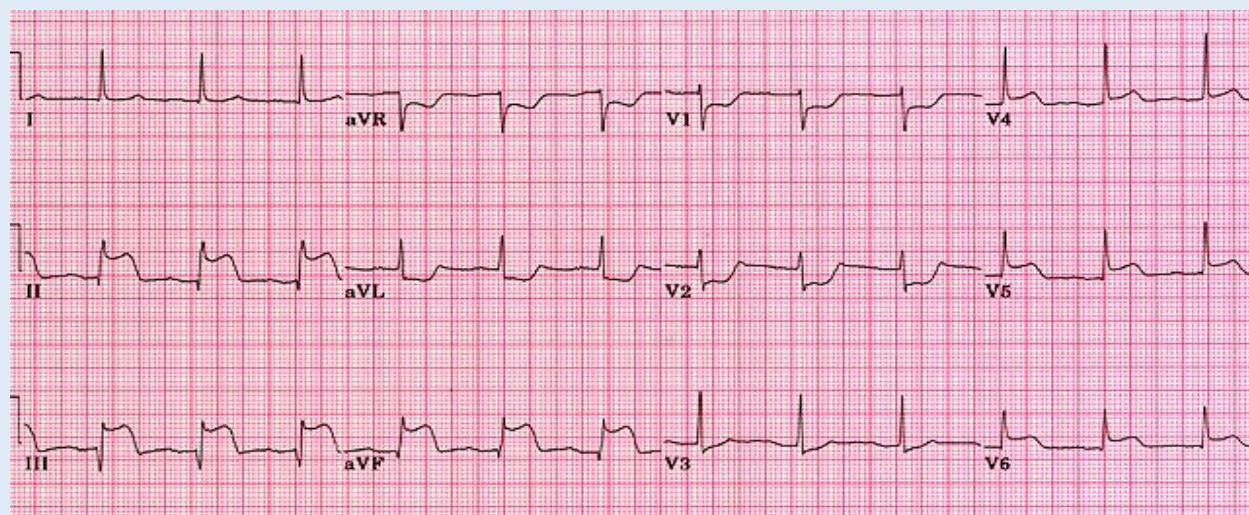
23)

Rhythm : regular with occasional irregularity .
 Rate : 75 / minute
 P wave : normal
 PR interval : normal
 QRS : wide + T opposite QRS in beat 5
 Diagnosis :
Ventricular Extrasystole .

24)



25)



24)

Rhythm : regular with occasional irregularity

Rate : 75 / minute

Axis : left

P wave : broad & notched (P mitrale)

PR interval : prolonged

QRS : QS pattern in V1

Wide QRS in V5 with T opposite QRS .

ST segment : normal

T wave : normal

Diagnosis :

Left atrial enlargement

Left bundle branch block

Ventricular extrasystole .

1st degree AV block

25)

Rhythm : regular

Rate : 75 / minute

Axis : normal

P wave : absent

PR interval : ??

QRS : normal

ST segment : elevated in II , III , aVF

Depressed in V 1 , 2 & aVL

T wave : normal

Diagnosis :

Acute inferior MI

Septal ischemia

Nodal rhythm